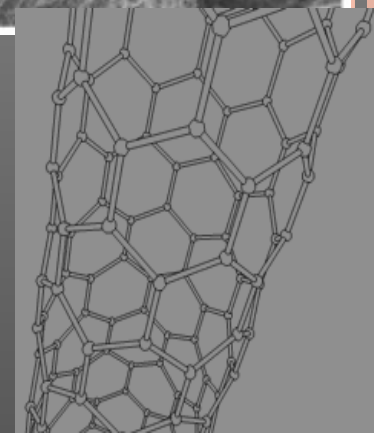




# Carbon Nanotubes

A scanning electron micrograph (SEM) showing a dense, interwoven network of carbon nanotubes. The nanotubes appear as thin, fibrous structures that are randomly oriented and interconnected, forming a complex mesh. A scale bar in the bottom left corner indicates a length of 2 μm.

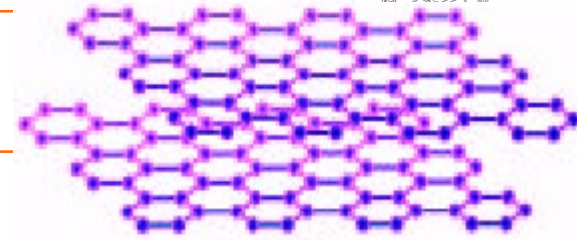
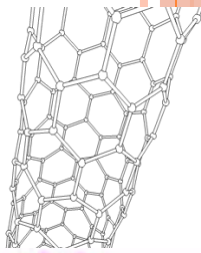
T.Revathy  
II M.Sc Chemistry  
Auxilium College



# Carbon

## Graphite (Ambient conditions)

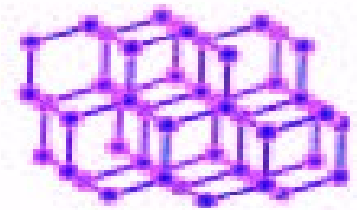
- $sp^2$  hybridization: planar



graphite

## Diamond (High temperature and pressure)

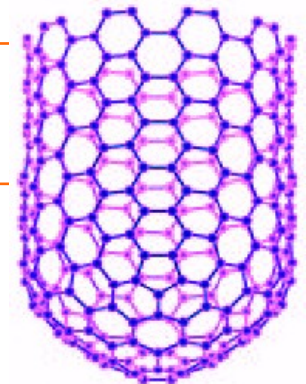
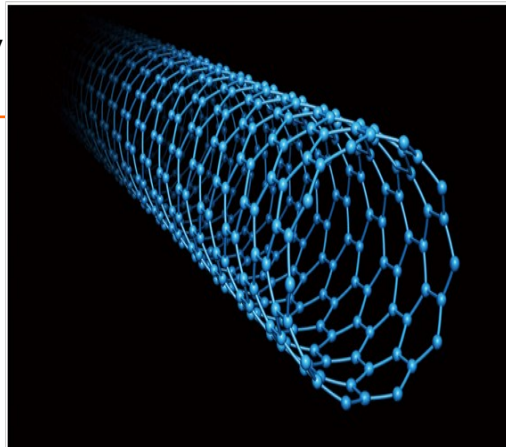
- $sp^3$  hybridization: cubic



diamond

## Nanotube/Fullerene (certain growth conditions)

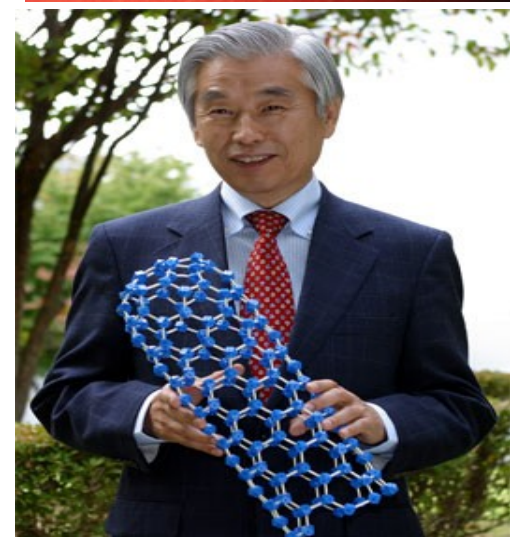
- $sp^2 + sp^3$  character: cylindrical



(10, 10) nanotube

# What Are Carbon Nanotubes?

Carbon nanotubes are a form of carbon, similar to graphite found in pencils. They are hollow cylindrical tubes and are 10,000 times smaller than human hair, but stronger than steel. They are also good conductors of electricity and heat, and have a very large surface area. Because of these



**Sumio Iijima**



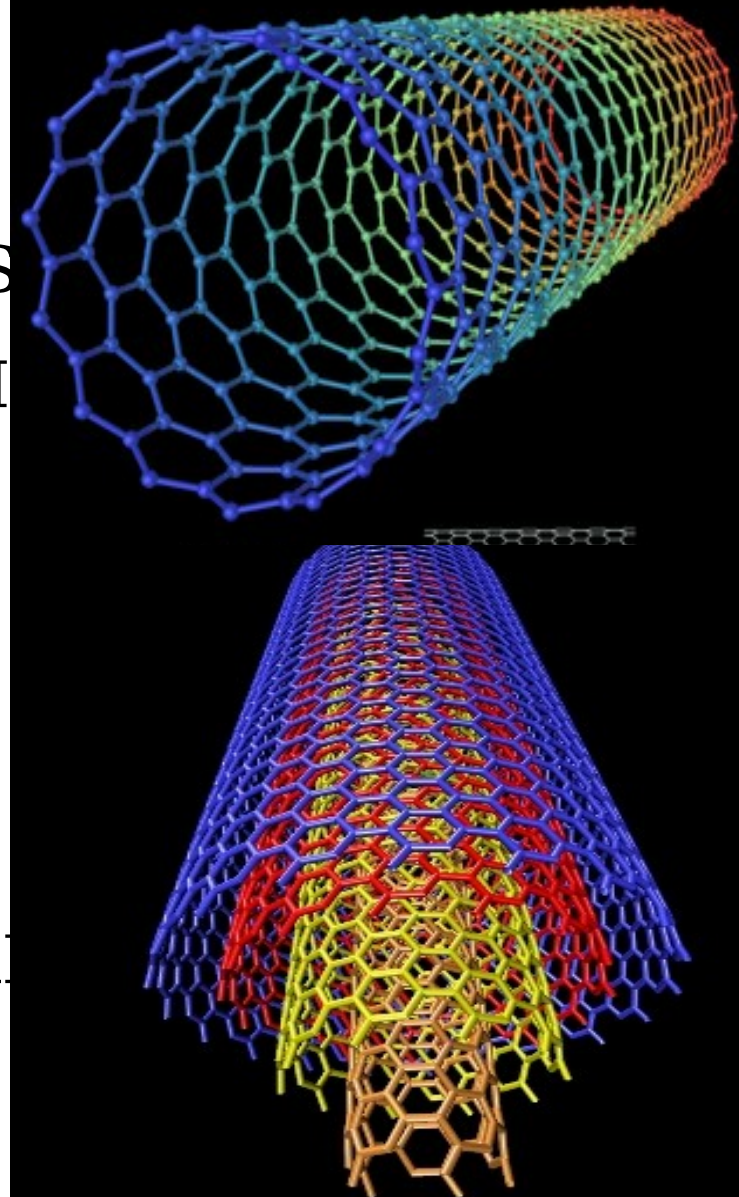
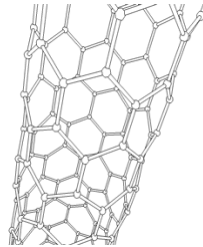
# Classification Of Carbon Nanotubes

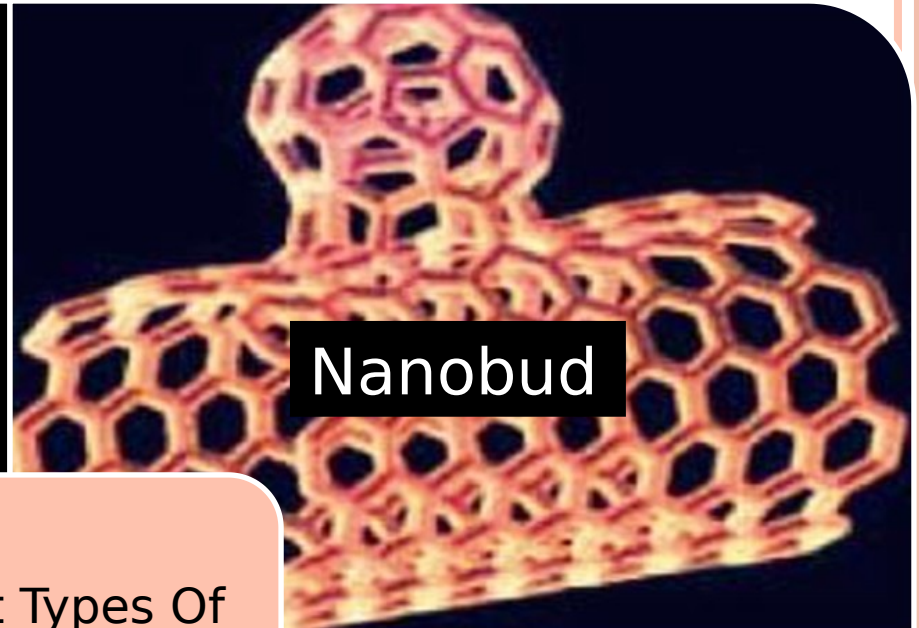
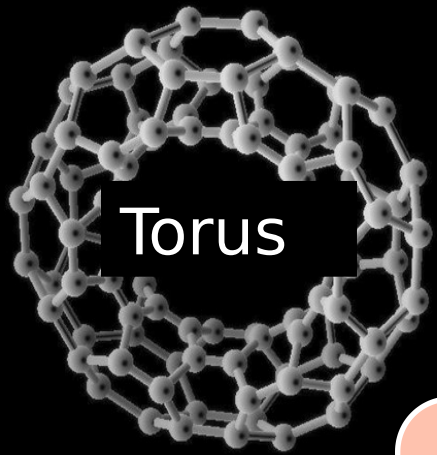
Classified mainly in two types:

1. Single walled nanotubes (SWNT)
2. Multi walled nanotubes (MWNT)

Other related structures:

- ❖ Torus
- ❖ Nanobud
- ❖ Peapod
- ❖ Cup-stacked carbon nanotubes



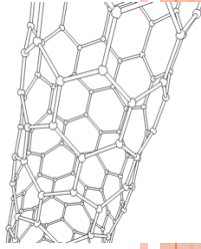


Different Types Of  
CNTs

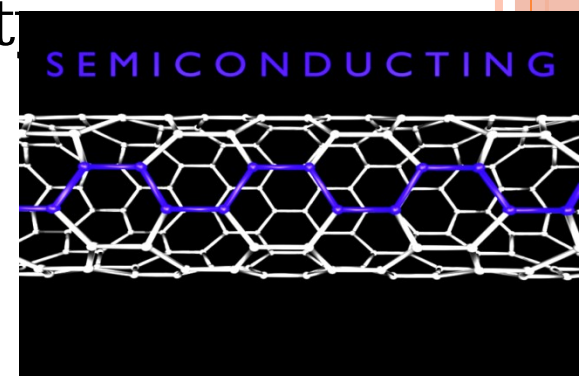


Cup-stacked carbon  
nanotubes

# Properties Of Nanotubes

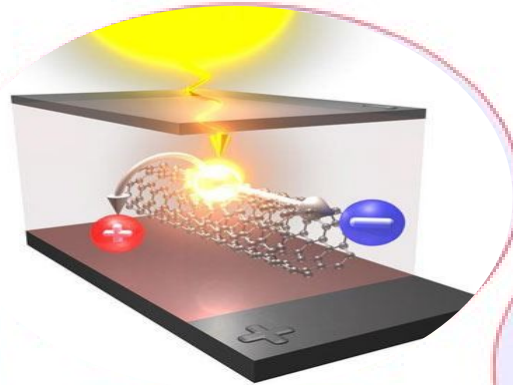
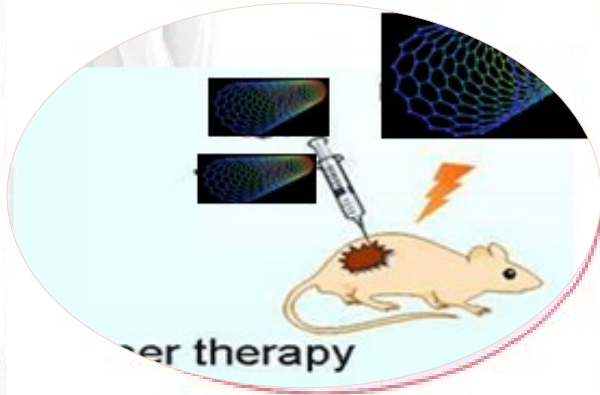


- CNTs have High Electrical Conductivity
  - Metallic and Semiconducting
- CNTs have Very High Tensile Strength
- CNT are Highly Flexible- can be bent considerably without damage
- CNTs are Very Elastic
- CNTs have High Thermal Conductivity

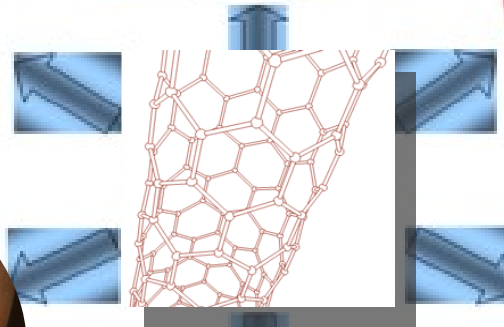




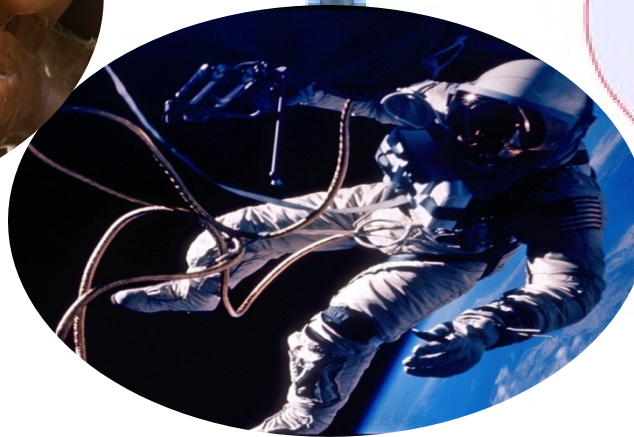
# Application Of Carbon Nanotubes



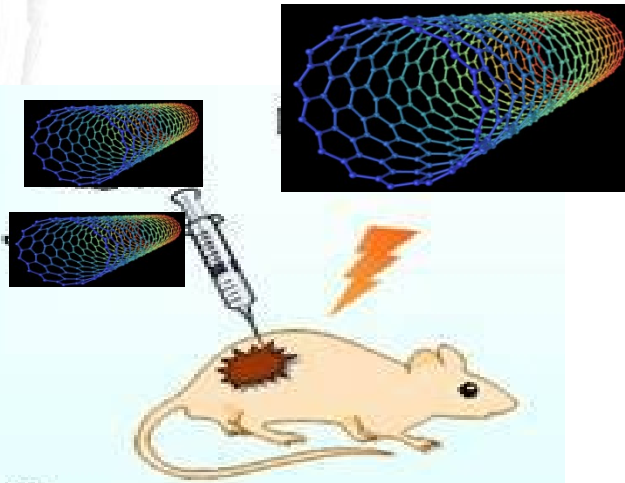
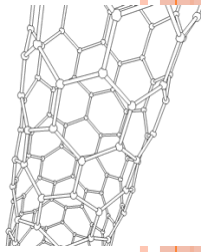
## Fuel cell & Hydrogen storage



## Super capacitor



# Tumor Blitz

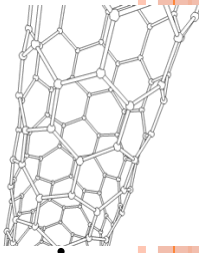


Cancer therapy

- ✓ In a recent study, researchers injected carbon nanotubes into kidney tumors in mice, and then directed a near infrared laser at the tumors.
- ✓ In the group that received the highest dose of nanotubes followed by a 30-second laser treatment, the tumors shrank and completely disappeared in 80 percent of the mice.
- ✓ The procedure didn't appear to damage the animals'

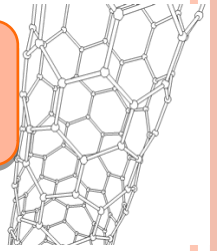


## Other Medicinal Application..

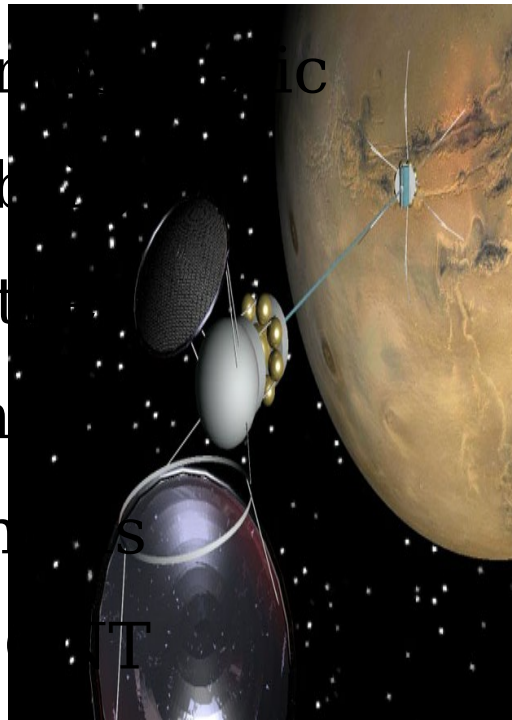


- ✓ Researchers at MIT have developed a sensor using carbon nanotubes embedded in a gel; that can be injected under the skin to monitor the level of nitric oxide in the bloodstream. The level of nitric oxide is important because it indicates inflammation, allowing easy monitoring of inflammatory diseases. In tests with laboratory mice the sensor remained functional for over a year.
- ✓ Researchers have demonstrated artificial muscles composed of yarn woven with carbon nanotubes and

# Space Elevator, Going Up



Nanotube ropes can act as cables for a space elevator, which could lift astronauts, cargo, or even tourists into orbit. The 62,000 milelong cables would have to be strong and flexible so they wouldn't collapse when buffeted by atmospheric storms and space debris, but light enough so they wouldn't collapse under their own weight. This is made possible using

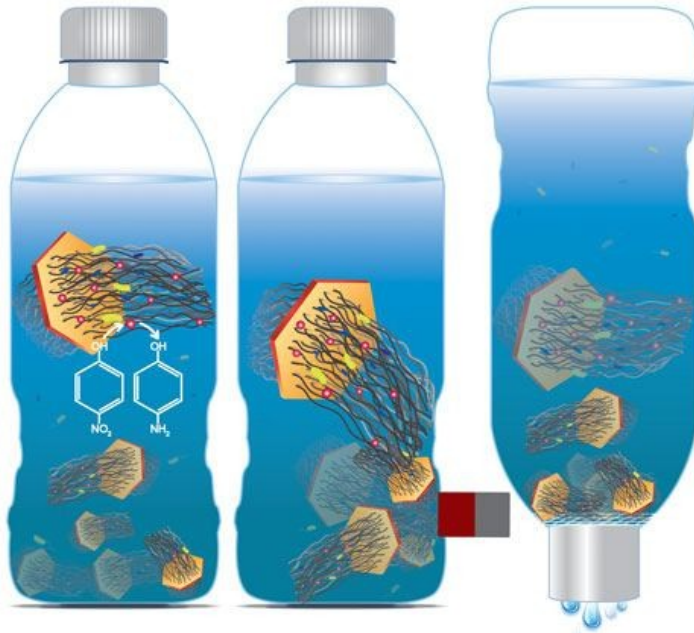


# Carbon Nanotubes For Cleaning Polluted Water

Scientists found that by using filters made of carbon nanotubes, pollutants could be removed more effectively



from  
charc  
filters



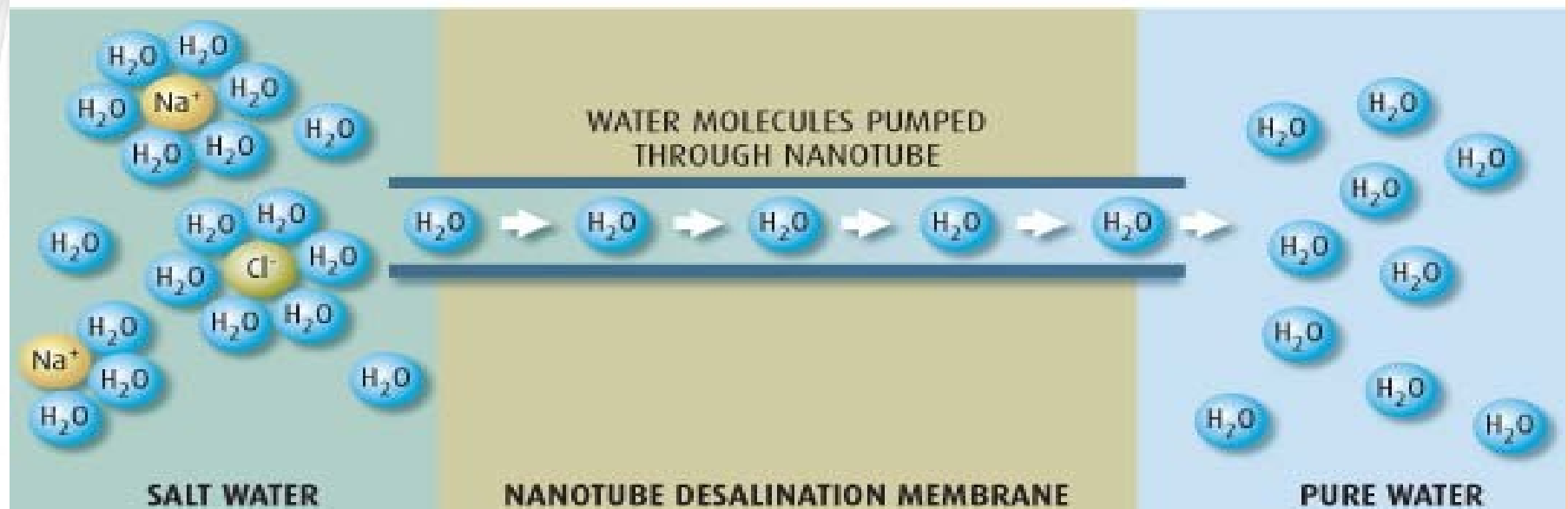
compared to common



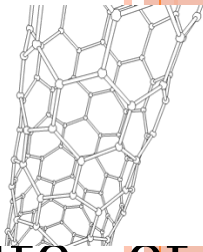
Recently published in  
The journal environmental science and technology



- ✓ Carbon nanotubes can be used as the pores in membranes to run reverse osmosis desalination plants.
- ✓ Water molecules pass through the smoother walls of carbon nanotubes more easily than through other types of nanopores, which requires less power.

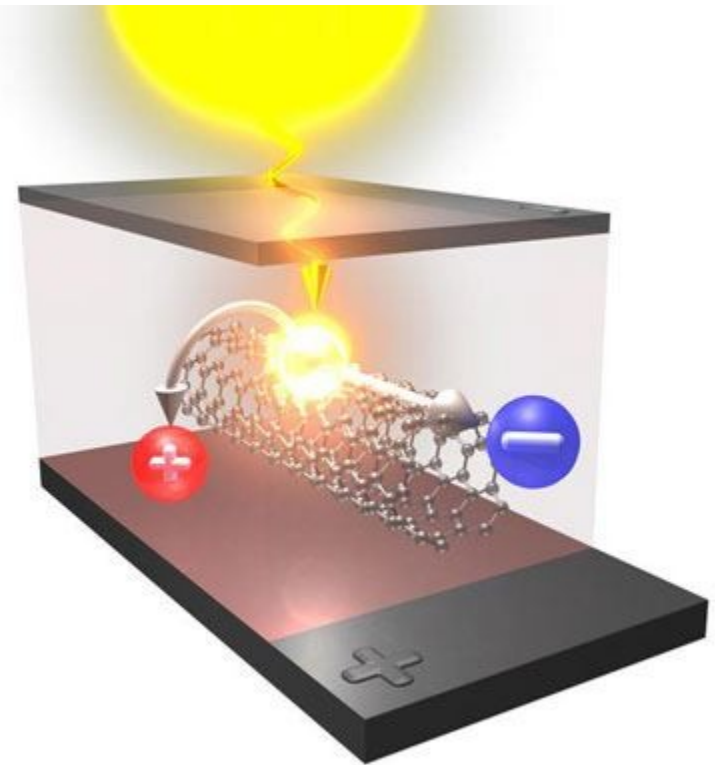


# Boosting solar energy storage

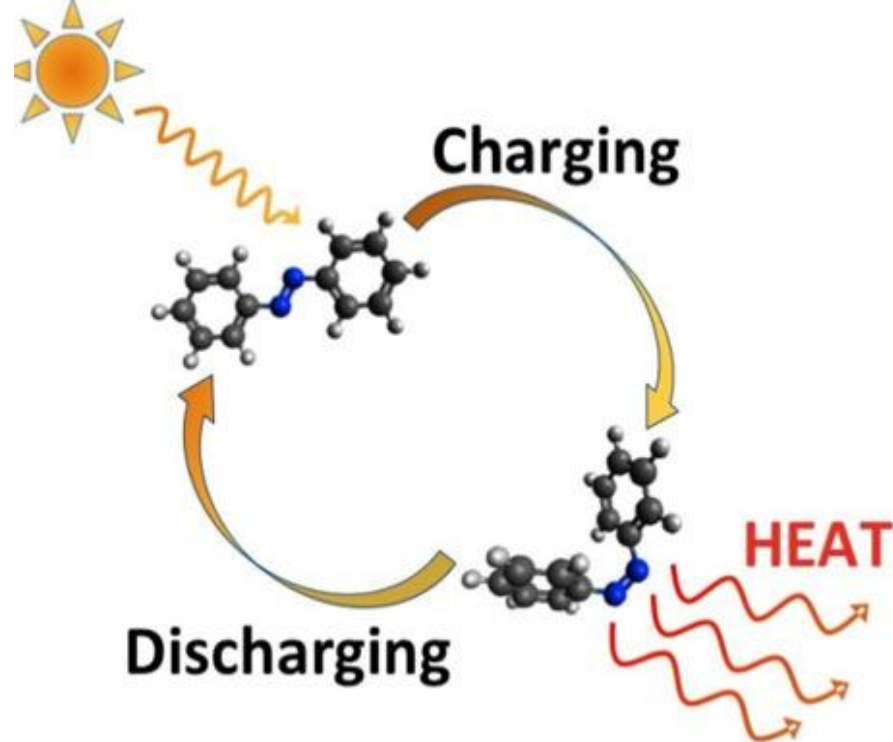
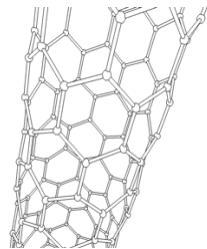


The Researchers at the Massachusetts Institute of technology (MIT) have announced a new solar thermal fuel that could store up to 10,000 times more energy

❖ The previous system of carbon nanotubes modified with azobenzene, a mix that is expected to provide the same energy storage per volume as lithium-ion batteries and can store solar energy almost



Research at the Massachusetts Institute of technology (MIT)



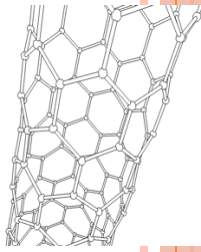
➤ It can also be recharged by simply exposing it to sunlight

✓ - The fuel has been studied using computational chemistry but not yet fully tested in the lab, so commercialization is still far off.





# Helping the Hydrogen Car



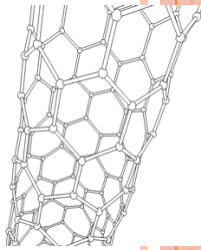
Hydrogen is a green energy fuel which could replace unsustainable and polluting fossil fuels.

This is because when it burns it gives off no carbon dioxide. Many of the car

companies are developing fuel cells run on hydrogen fuel largely by the expense of making fuel cells. But Later researchers found that bundles of carbon nanotubes doped with nitrogen form a



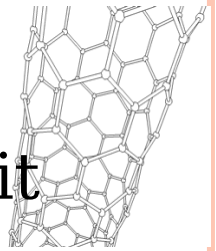
# Flexible, Bendable Electronics



- ✓ Researchers at the University of Tokyo took a step in that direction in May when they constructed a display made of organic light emitting diodes (OLEDs) paired with a rubbery, nanotube based conductor



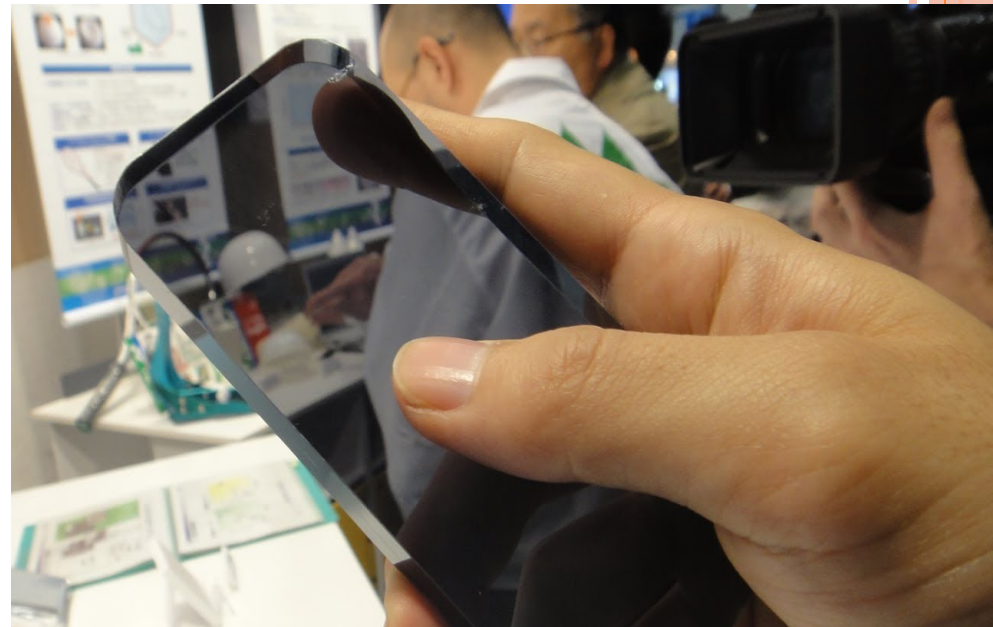
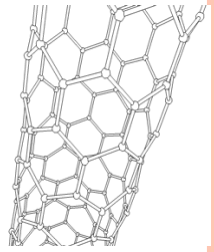
The organic compounds in an OLED system emit light when an electric current is passed through them, and they need no backlight, making them thinner than traditional displays. As nanotubes are natural semiconductors, they channel the electricity to the organic compounds.





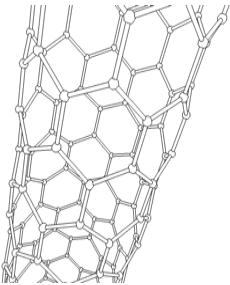
## Other applications in this area include:

- ✓ Carbon nanotubes used to direct electrons to illuminate pixels, resulting in a lightweight, millimeter thick "nanoemissive" display panel.
- ✓ Transparent, flexible electronic devices using arrays of nanotubes



# Carbon Nanotubes and the Environment

- ❖ Carbon nanotubes are being developed to clean up oil spills. Researchers have found that adding boron atoms during the growth of carbon nanotubes causes the nanotubes to grow into a sponge like material that can absorb many times it's weight in oil. These nanotube sponges are made to be magnetic, which should make them easier to retrieve once they are filled with oil.



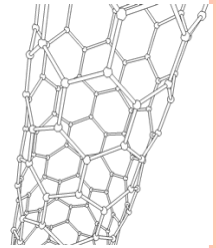
# What's The Recent Research On CNTs?

The research concentrates on producing carbon nanotubes and hydrogen from waste plastics.

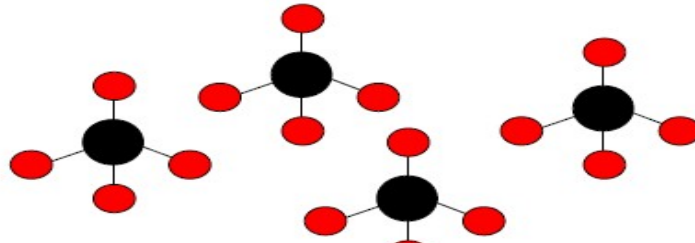
**HEAT**



**HEAT**



Plastics are heated in  $N_2$  atmosphere



They break down to form methane and other gases



**Carbon nanotubes + Hydrogen**



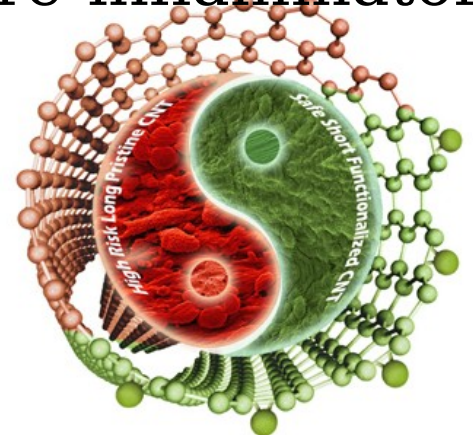
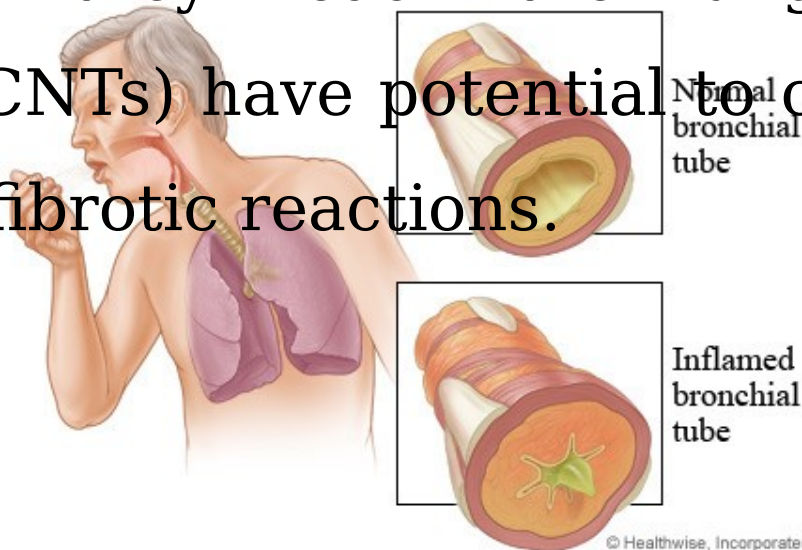
A catalyst breaks them down further into carbon and hydrogen.  
Carbon grows as carbon nanotubes on the catalyst surface.



# Toxicity of CNTs

❖ According to scientists at the National Institute of Standards and Technology, carbon nanotubes shorter than about 200 nanometers readily enter into human lung cells similar to the way asbestos does, and may pose an increased risk to health.

❖ If they reach the lungs, CNTs (SWCNTs and MWCNTs) have potential to cause severe inflammatory and fibrotic reactions.



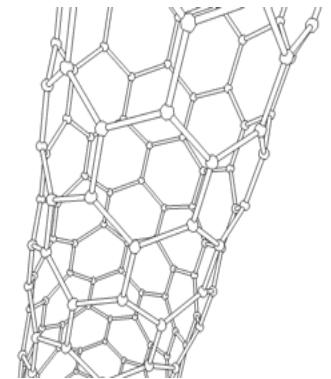
# Conclusion

- ✓ Carbon nanotubes hold great promise for a variety of industrial, consumer, and biomedical applications, due to their outstanding and novel properties.
- ✓ Over the last two decades many different types of CNTs have been produced at the industrial scale. Therefore, the exposure risk to humans associated with such a mass scale production has also increased substantially.
- ✓ CNTs are also intended for use in many biomedical applications, and therefore their biocompatibility, bio distribution and fate needs to be carefully assessed



# References

- ✓ [www.sciencedaily.com?CNT](http://www.sciencedaily.com?CNT)
- ✓ [www.En.wikianswers.org/CNT](http://www.En.wikianswers.org/CNT)
- ✓ [www.images.google.com/CNT](http://www.images.google.com/CNT)
- ✓ [www.youtube.com/CNT](http://www.youtube.com/CNT)
- ✓ Understanding Nano.com
- ✓ [www.asme.com/making CNT safer](http://www.asme.com/making CNT safer)
- ✓ [www.nanotechnow.com/currentuses](http://www.nanotechnow.com/currentuses)
- ✓ Carbon Nanotubes: Introduction to Nanotechnology 2003, Mads Brandbyge.



# **The Next Big Thing Is Really Small”**



Thank you...

